Cm-scale Heterogeneity in Degradation - Potential Impact on Leaching of MCPA through a Variably-Saturated Macroporous Clayey Till

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ABSTRACT BODY: Recent research has revealed a large variation in pesticide mineralization potentials, but little is known about the scale at which these heterogeneities impact the spreading of contaminants. A modeling study aiming at quantifying how heterogeneous degradation potentials in agricultural soil will affect MCPA degradation and leaching was conducted. 2D-distributions (96-well micro plate mineralization assay) of the mineralization potentials of phenoxy acid herbicides (MCPA, 2,4-D) representing layers in the upper meter of variably-saturated clayey till were applied. The rapid mineralization measured was represented by Monod mineralization kinetics, whereas the rest were either represented by slow 0-order mineralization kinetics or no degradation. Five 3D-modelling scenarios were set up using the COMSOL Multiphysics 4.1 toolbox (COMSOL Inc., Burlington, MA, USA): 1) simple matrix flow of water with no biodegradation of the MCPA at all nodes; 2) preferential flow (including a wormhole) of water with no biodegradation of the MCPA at all nodes; 3) simple matrix flow of water with average biodegradation of the MCPA at all nodes, which corresponds to results derived from a conventional homogenized soil sample; 4) simple matrix flow of water with the observed high variation in biodegradation of the MCPA corresponding to random variation in degradation; and 5) vertical structure in water flow combined with vertically structured degradation (defined hot spots and cold spots), which corresponds to a situation where both flow and degradation are associated with macropores/wormholes. Results show that cm-scale heterogeneity in degradation potential with simple matrix flow has a negligible effect on MCPA leaching at one meter below soil surface. By introducing a wormhole in the low-permeable 3D-soil modeling domain, however, the risk of MCPA-leaching below one meter depth increase drastically with low degradation potential along the wall of macropores/wormholes.

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